SEED DISPERSAL (AND ESTABLISHMENT) IN INVASIVE *RHODODENDRON PONTICUM:* IMPLICATIONS FOR MANAGEMENT

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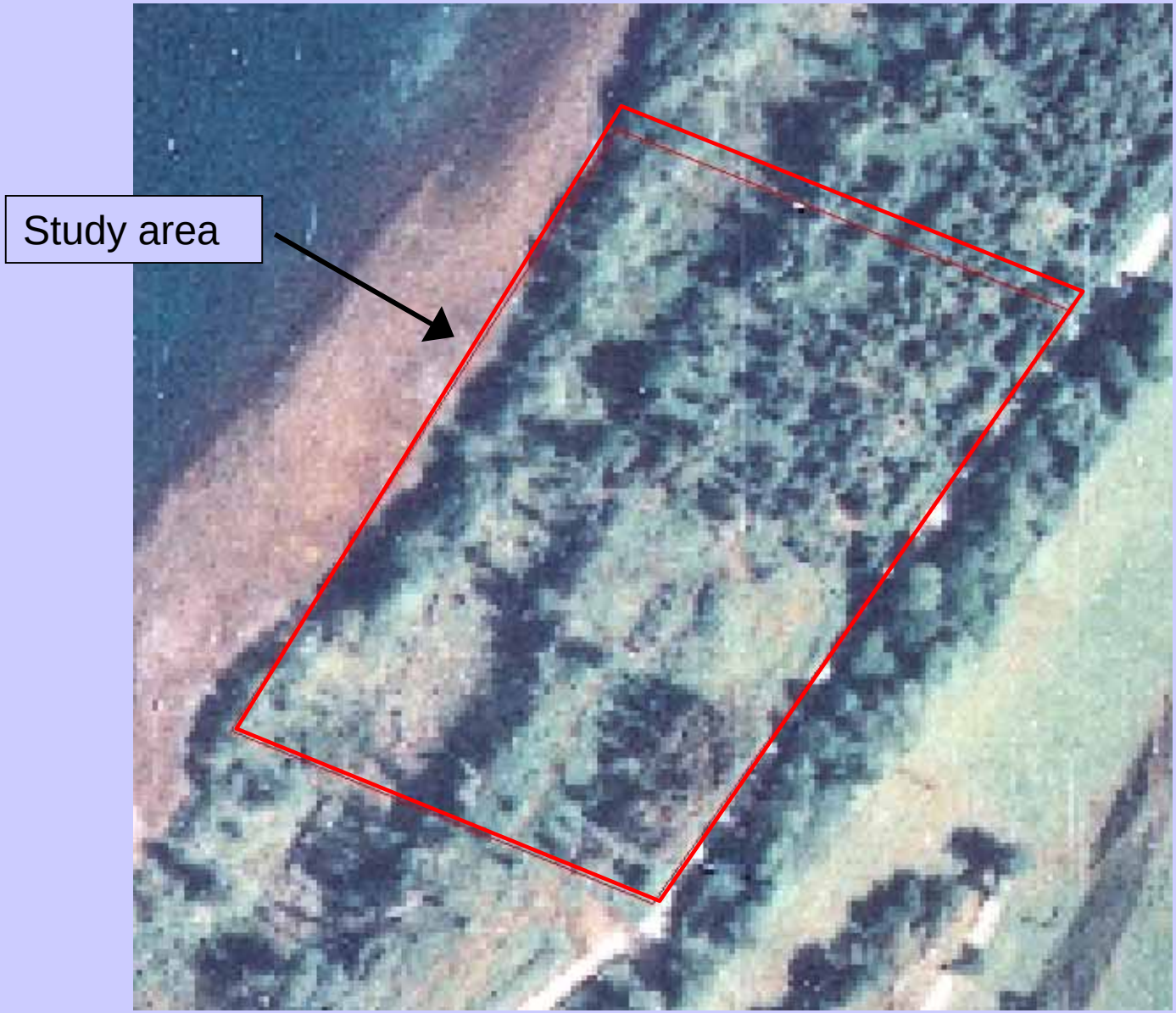
Recent developments in our understanding of *R. ponticum* ecology

- Pollination (Stout et al., 2006)
- Establishment (Stephenson et al., 2006)
- Growth and germination rates in native and non-native habitats (Erfmeier & Bruelheide, 2005; Esen et al., 2004)
- Economic consequences of invasion (Dehnen-Schmutz et al., 2004)
- Methods of removal (Edwards, 2006)

Establishment Study

- There are many qualitative descriptions relating to pollination, seed dispersal, germination and establishment for *R. ponticum* but all require quantification.

Methods



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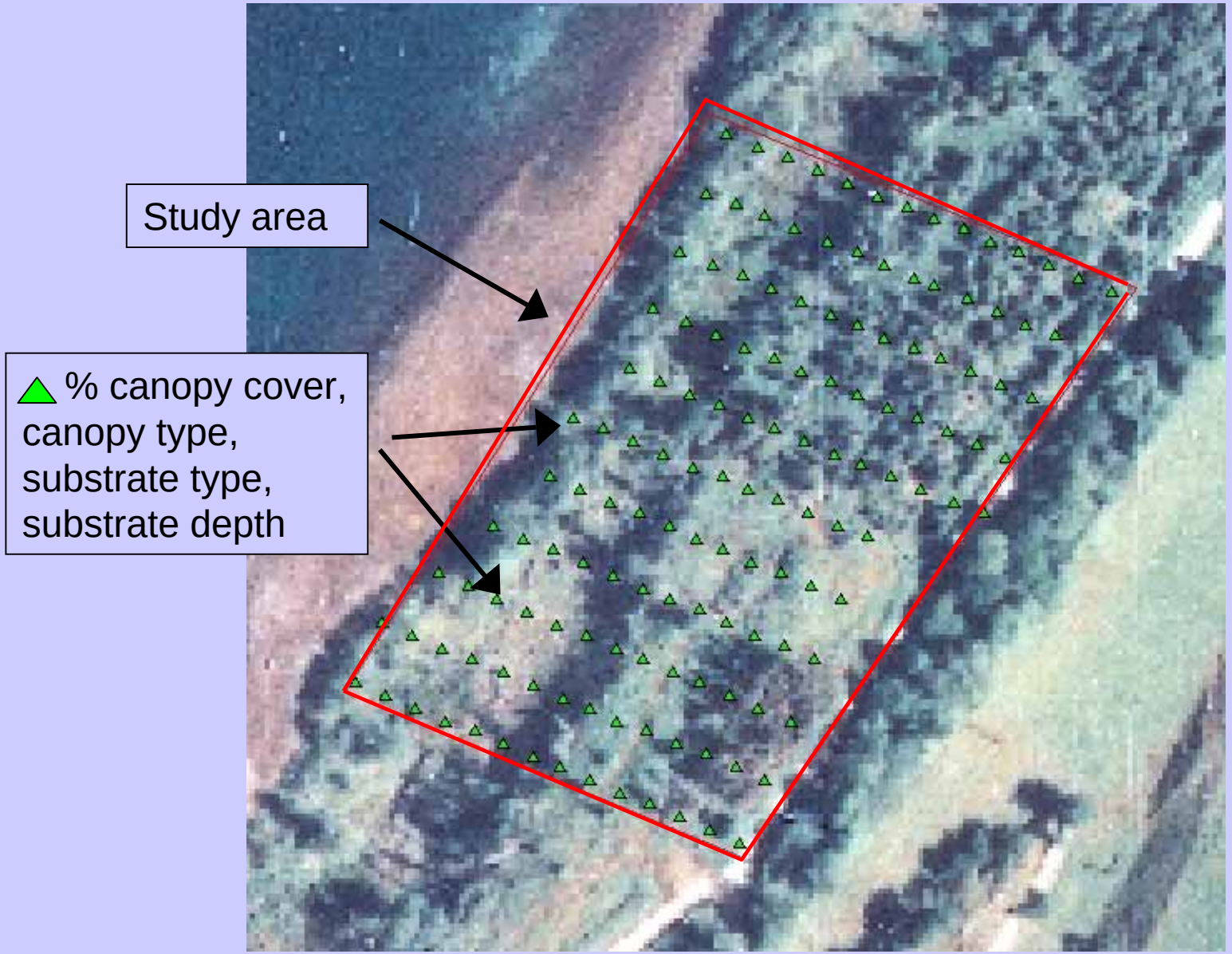
Study area
▲ % canopy cover, canopy type, substrate type, substrate depth

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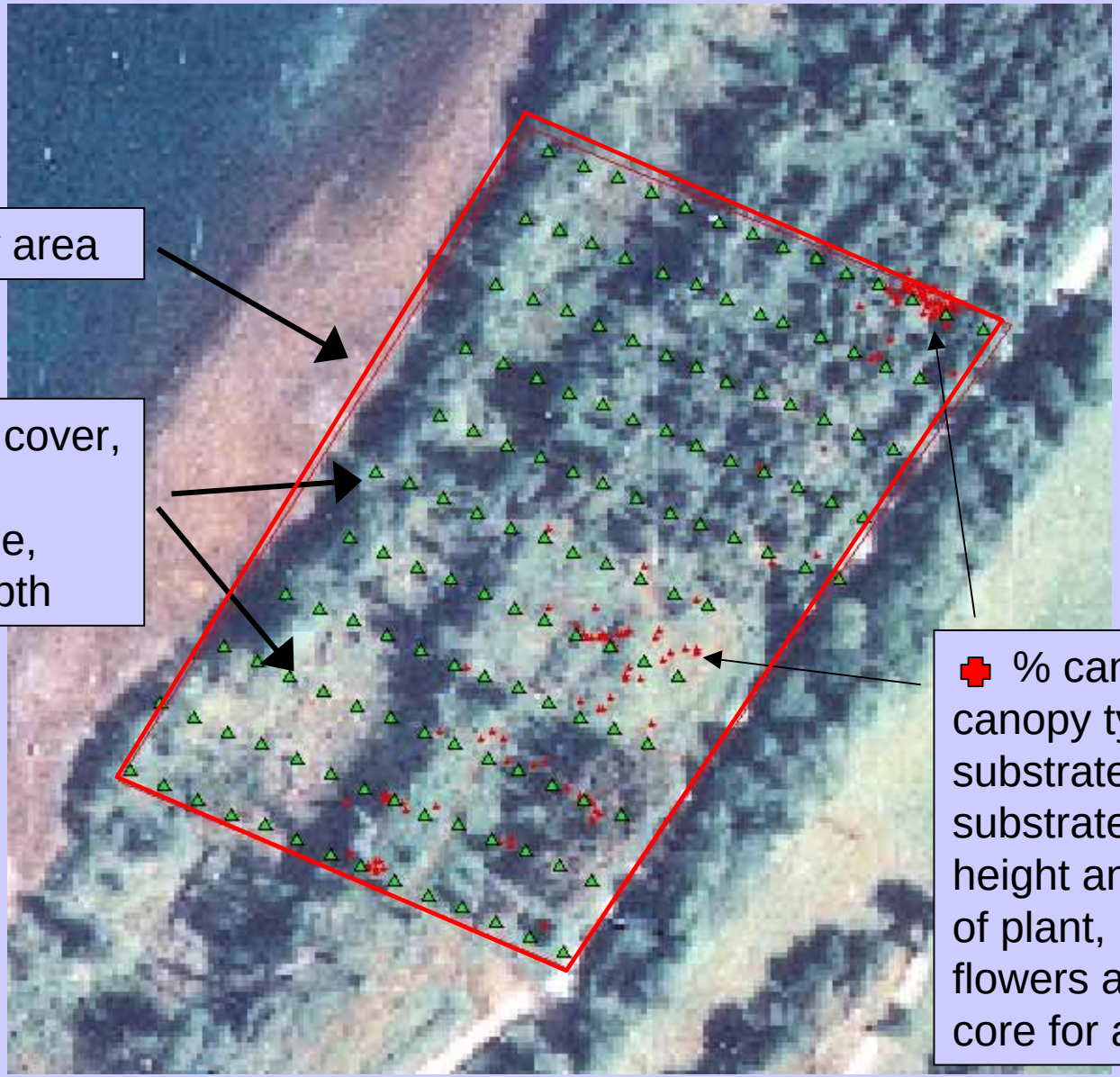
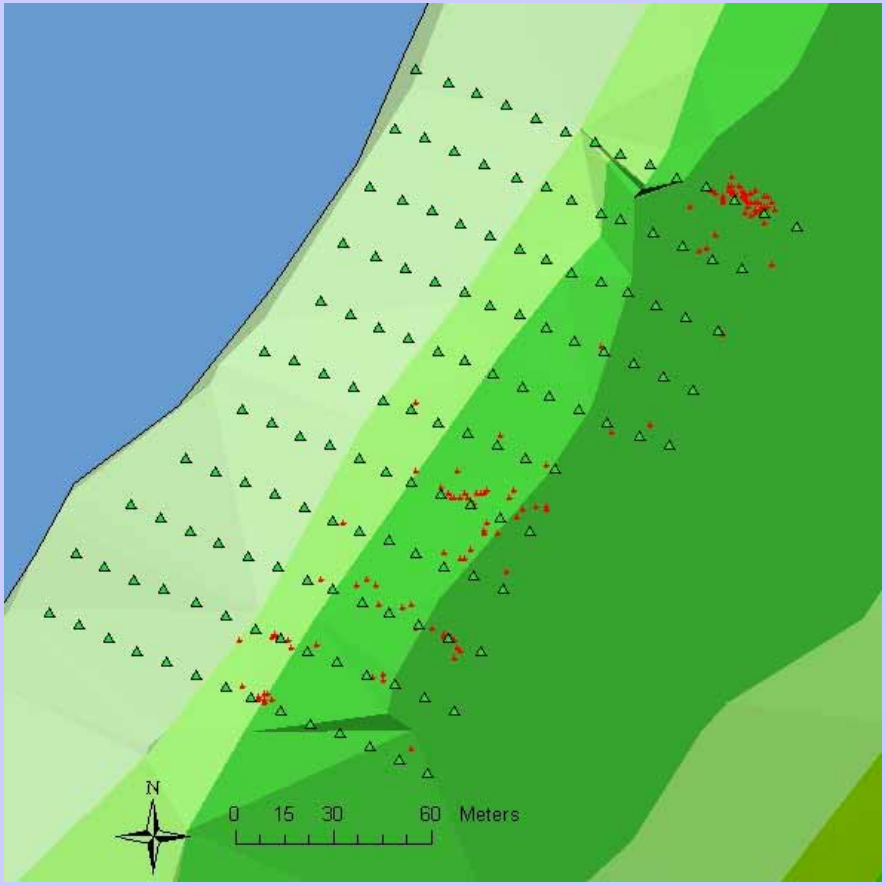
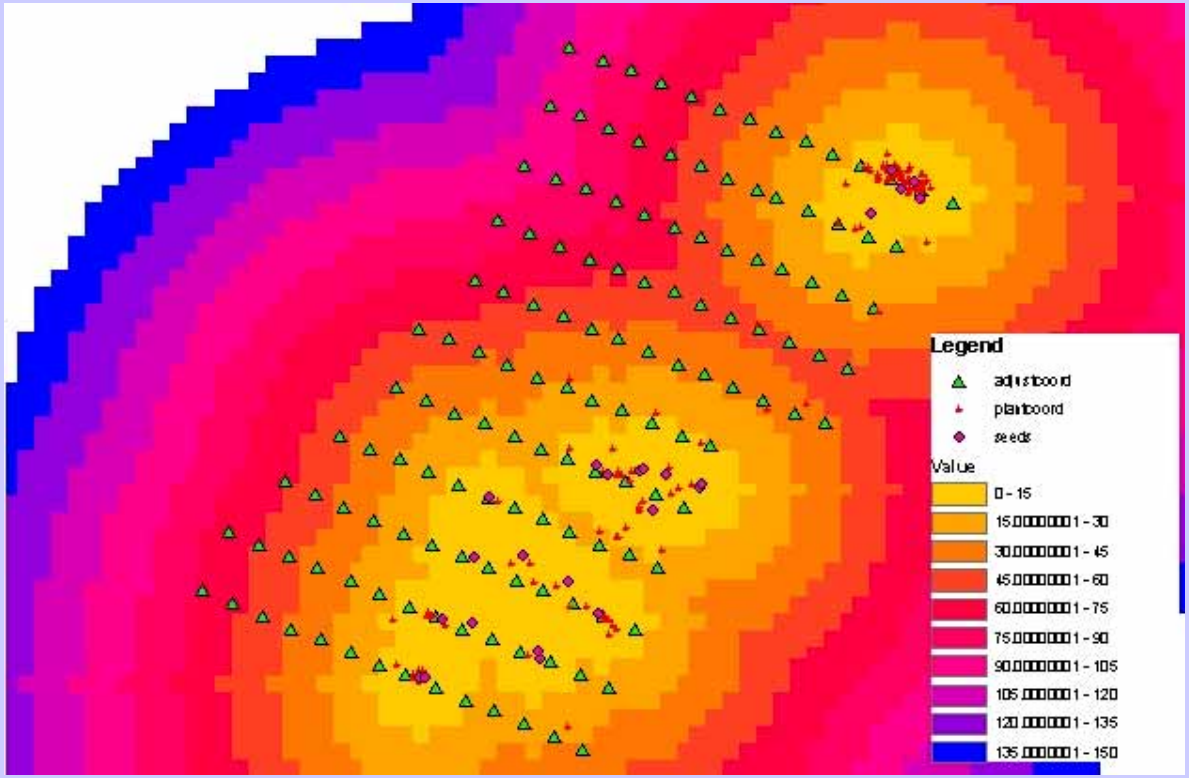

Study area
▲ % canopy cover, canopy type, substrate type, substrate depth
✚ % canopy cover, canopy type, substrate type, substrate depth, height and diameter of plant, presence of flowers and seeds, core for ageing



Height, slope and aspect values for the study area were generated from an OS Land-form Panorama Digital Terrain Model at a 5m x 5m resolution.



Mapping out the positions of plants with seeds allowed the calculation of the straight line distance to the nearest seed source for each cell on the grid (5m x 5m).

Model Results

- The probability of finding a seedling:
  - Decreases as distance from a seed source increases.
  - Increases with increasing altitude
  - Decreases with increasing substrate depth
  - Is higher on dead tree material compared to moss or litter
  - is higher on moss compared to litter.
  - No seedlings were found in habitats containing grass or bracken.

- Establishment is higher on dead tree material compared to moss or litter
  - Thin layers of moss have previously been described as being important
  - However, the full importance of dead tree material for *R. ponticum* has not been explicitly explored before now.

For details see: Stephenson et al. 2006. Ecological Modelling 193: 747-758.

Seed dispersal

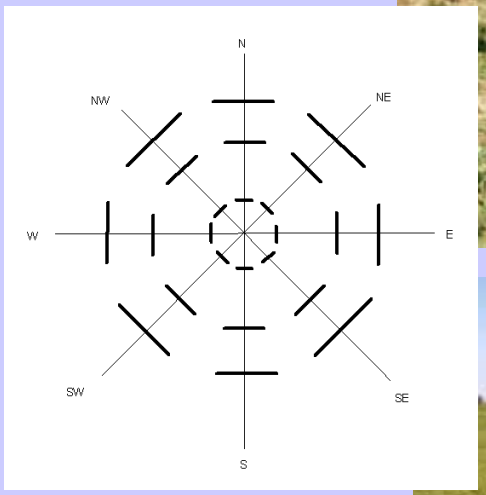
- What we know:
  - Mature plants can produce hundreds of thousands of seeds each year
  - The morphology and small size suggest wind as primary dispersal agent
  - Assumed that seeds are dispersed >100m on strong winds
- What we don’t know:
  - Anything quantitative about the shape of the dispersal kernels
  - The mean and max distances travelled by seeds under different wind conditions
  - The extent of the tail of the dispersal kernel

Aims

- Quantify short and long distance dispersal (i.e. characterise the shape and the tail of the seed kernel)
- Test whether a simple mechanistic model can describe controlled and natural releases of seeds given windspeed, habitat type, terminal velocity and the height of seed release
- Compare patterns of seed dispersal during controlled releases with that produced over a longer period of seed release under natural conditions.

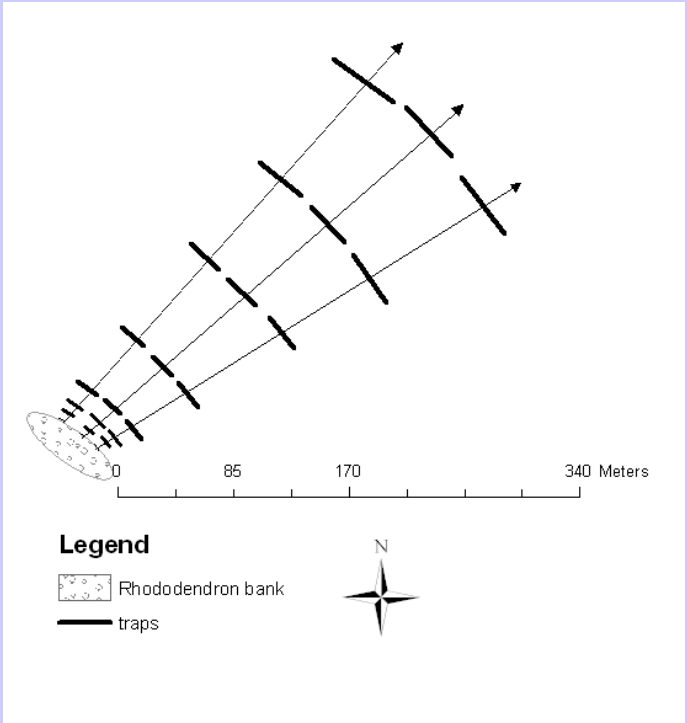
Field Experiments

- Controlled experiments
  - 10 trials
  - 200,000 seeds released during each trial
  - 2 release heights – 2m and 3.5m
  - Seed traps in 8 compass directions at 0.1, 1, 2, 5, 10, 20, 50 and 100m
  - Wind data collected from weather station on site



Field Experiments

- Natural experiment
  - Seed traps arranged in front of a natural stand of *R. ponticum*
  - Seed traps at same distances as controlled experiment
  - Traps left for 6 weeks during period of peak seed release
  - Wind data collected from nearby weather station



Mechanistic wind dispersal model

- WINDDISPER (Nathan et al. 2001) was parameterised to generate expected seed dispersal curves for comparison with the observed seed distributions.

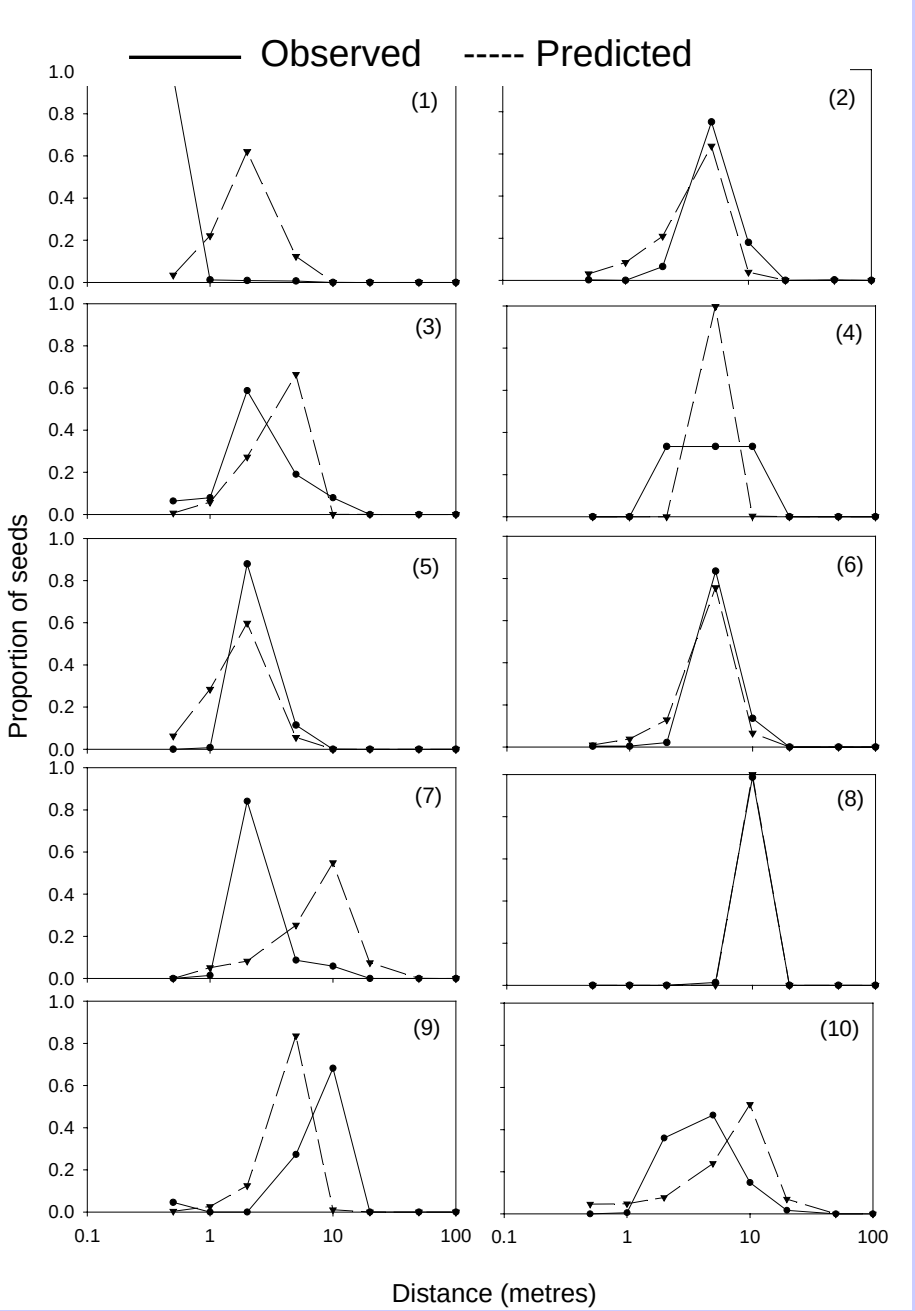
- Constant parameters:
  - 200,000 seeds released
  - Vegetation roughness = open, short grass
  - Terminal velocity ($0.98 msec^{-1}$ (± 0.14))
- Variable parameters:
  - Release height (2 and 3.5m for controlled release, 5 +/-1m for natural release)
  - Mean and SD of wind speeds

Nathan R, Safriel UN, Noy-Meir I (2001) Field validation and sensitivity analysis of a mechanistic model for tree seed dispersal by wind. *Ecology* 82: 374-388.

Results

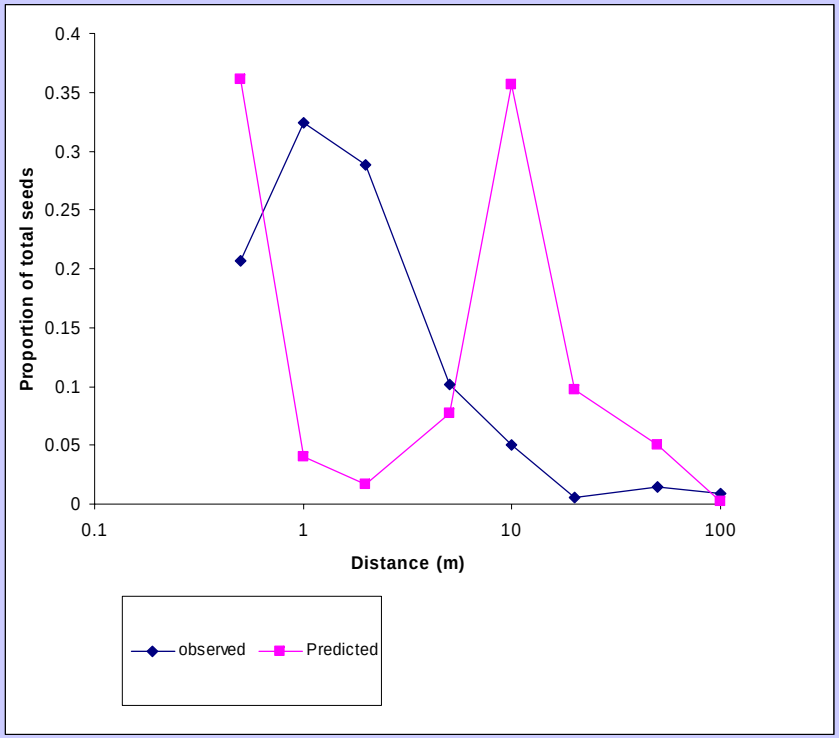
- Controlled experiments
  - 99.8% of seeds were found <= 10m from release point
  - greatest number of seeds at 5m
  - only 0.001% travelling 50m or more
  - No significant difference between observed and simulated modal and maximum dispersal distances

NB: mean wind speed during all trials was <5msec^{-1}



Results

- Natural release experiment
  - 97.1% of seeds were found on traps <= 10m from release point
  - greatest number of seeds at 1m
  - 0.02% of seeds travelled >= 50m
  - 0.01% landed on traps at 100m.
  - Mean daily wind speed data predicted more seeds landing at 0.5m than observed, and a fatter tail at distances greater than 20m than observed



Fit of mechanistic model

- The model provided a much better fit to the controlled release data
- This could either be due to
  - the model performing better under low wind speeds perhaps due to uncertainty over the trajectories of seeds dispersed at higher windspeeds
  - or the model performing better when the exact wind conditions at the point of release are known

Conclusions

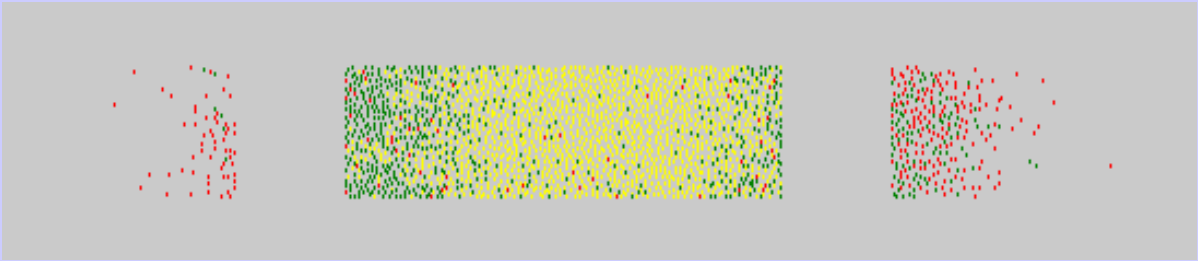
- The majority of *R. ponticum* seeds travel less than 10m
- Long distance dispersal (up to 100m) is possible under the wind speeds observered during the natural release (up to 50msec^{-1})
- WINDDISPER (Nathan et al. 2001) can provide a good description of the dispersal kernel under low wind conditions and when the conditions at the point of release are known
- This highlights the need to investigate the conditions required for abscission eg if only low resolution wind speed data is being used to parameterise such models should we be using the daily mean wind speed or daily maximum wind speed?

Applied use of this data

- This data and the mechanistic dispersal model, along with other life-history data are being used to parameterise a model investigating control strategies for *R. ponticum*
  - A spatially-explicit individual based model parameterised for *R. ponticum*
  - Investigates possible control strategies in different habitats

Example

- Aim = containment of *R. ponticum* within specified area
- Habitat = linear
- Mechanistic model parameterised with distribution of mean wind speeds ($9msec^{-1}$ +/- $6msec^{-1}$) and max wind speed ($15msec^{-1}$ +/- $7msec^{-1}$)
- One point of introduction
- Strategy for containment = corridor of unsuitable habitat at each end of habitat (50m, 100m or 150m)
- Measure of success/failure = number of escapee plants up to 80 years post introduction



Conclusions

- Empirical data on invasive species ecology, such as seed dispersal data can be used to parameterise models of invasion
- Such models can be used to investigate a vast number of scenarios
- Future aim is to develop the model to accept real landscapes through GIS and incorporate real economic scenarios to aid land managers and conservationists in their control efforts

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